TOF-AMS Results from the Ground

AMS Users Meeting – Jülich August 2005

Outline

First Field Deployment – PMTACS-NY 2004
FACE 2004
HNY 2004/2005
Instrument Characterization Experiments
PMTACS-NY: Particulate Matter Technology Assessment and Characterization Study – New York

One of the US-EPA ‘Supersites’; Measurements to compare with PMTACS-NY 2001 summer campaign

One of the main objectives: “.. test and evaluation of new measurement technologies ..”

Measurement site: Campus of Queens College

~15-20 km east of Manhattan, 300 – 1500 m to next major Highways (I-495, I-678)

Site and Instrumentation

AMS/TOF-AMS Inlet

Other Instrumentation:
- R&P Nitrate/Sulfate Monitors
- PILS
- TEOMs
- SMPS, nano-SMPS, CPCs
- GTHOS (OH/-HO2-Measurement)
- TDL
- On-line GC-MS
- Filter/Gas Phase...
Mass Concentrations:

Comparison with Q-AMS:
Recovery Nitrate 91%
Sulfate 78%
Organics 47%

Correlation Coefficients
$R^2 = 0.83 - 0.95$

→ Proof of on-line aerosol measurement capability of TOF-AMS; but quantification problems to solve

![Graphs showing mass concentrations of various components over time]

Size Distributions:

m/z 30: Nitrate  
m/z 48: Sulfate

5-min Time Resolution → Excellent Signal/Noise!
Size Distributions – Comparison TOF/Q-AMS:
(2-hour averages, examples)

→ Good agreement of size distribution data; TOF-AMS has significantly better S/N than Q-AMS

Single Particles - Examples for Typical Single Particle Data

Time series of the signal at several m/z shows increase at same time

→ Averaged mass spectrum for ‘single particle event’

1) Internally mixed NH₄NO₃ – (NH₄)₂SO₄ Particle with some organics
2) Pure (NH₄)₂SO₄ Particle
3) NH₄NO₃ Particle with some organics

→ Statistical analysis of single particle events ...
Single Particles – Statistical Analysis

Correlation of species signal intensity in individual particles → Information about internal/external mixture

FACE 2004

The Feldberg Aerosol Characterization Experiment 2004:

July/August 2004 on Kleiner Feldberg/Taunus 20 km NE Frankfurt

Objectives:
- Instrument Evaluation
- CCN Measurements
- Particle Nucleation
- Characterization of ambient aerosol
Comparison TOF-AMS/Q-AMS: Mass Concentrations

- Good correlations with R² of 0.69 – 0.91
- Recovery of TOF-AMS compared to Q-AMS: 1.01 – 1.15

→ Much better agreement between the instruments compared to PMTACS-NY 2004!

Comparison TOF-AMS/Q-AMS: Size Distributions

- Significant difference in Organics size distribution for small particles
  → Due to problem with DAQ?

→ Comparison TOF-AMS / SMPS:
  → Good agreement of Org and SO₄ with SMPS data
The 'Happy New Year 2004/2005' Campaign:

**Measurement Site:**
- Garage in bridge post
- Close to Rhine bank (15 m)
- Next to major street (5 m)

**Instrumentation:**
- TOF-AMS: time resolution 5 min
- CPC: time resolution: 1 s
- PTR-MS: Measurement of gas phase concentrations of species with high proton affinity; time resolution 1.5 min

**Time Series of Individual Species:**
- Intense fireworks contribution for species associated with combustion (Number Conc, Sulfate, Chloride, Organics, m/z 44 (OOA), Methanol, Acetonitrile, Acetone, Acetaldehyde)
- Small or no fireworks contribution for species associated with traffic (m/z 57 (HOA), Benzene, Trimethylbenzene, Toluene, Xylene) and for particulate Nitrate and Ammonium
**Fireworks Aerosol - Dynamics:**

- Massively increased aerosol loadings exactly at 0:00; aerosol dominated by SO₄, Org, K
- 'Champagne-Dip' found after initial peak
- Similar dynamics for all aerosol and trace gas species
- Maximum aerosol mass conc. (PM1.0) >> 300 µg/m³ (K and other species not calibrated; metals and metal oxides not measured)

**'Ambient' Aerosol:**

- Broad Org, SO₄, m/z 57 size distributions with small particles
- Traffic-related diurnal patterns of Number Conc., Org, m/z 57, Aromatics; good correlations of these parameters
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- Site strongly affected by traffic
**Instrument Characterization**

**P-TOF Calibration at various ambient pressures:**

- Ambient pressure varied from 200 – 1000 hPa
- Size calibration as a function of $p$

$\Rightarrow$ Particle velocity decreases with decreasing ambient pressure

$\Rightarrow$ Pressure changes of 40 hPa (e.g. Due to weather changes) introduce $d_{va}$ error of ~ 7% !

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**Inlet Flow Calibration at various ambient pressures:**

- Volumetric inlet flow nearly constant down to 300 hPa
- Mass flow proportional to ambient pressure
- Lens pressure proportional ambient $p$

$\Rightarrow$ Lens pressure $\propto$ mass flow, NOT $\propto$ volumetric flow!

$\Rightarrow$ Error in calculation of $Q_{in}$ (and mass concentration) at 40 hPa pressure change: 4 % (NOT corrected for by AB correction!)
Summary

• TOF-AMS successfully deployed in several field campaigns
• After solving initial problems TOF-AMS seems to be as reliable as Q-AMS
• Possibility of single particle analysis demonstrated

Outlook

• Several data acquisition, operation and data processing issues have still to be solved
• We need more instrument characterization
• We need better calibration routines
• We need to do much more for single particle analysis